Evidence for and Implications of a Viscosity Increase in the Mid Mantle

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The viscosity structure of Earth's deep mantle affects the thermal evolution of Earth, the ascent of mantle plumes, settling of subducted oceanic lithosphere, and the mixing of compositional heterogeneities in the mantle. Based on a reanalysis of the long-wavelength non-hydrostatic geoid, we infer viscous layering of the mantle using a method that allows us to avoid a priori assumptions about its variation with depth. We detect an increase in viscosity at 800- to 1200-kilometers depth, far greater than the depth of the mineral phase transformations that define the mantle transition zone. The viscosity increase is coincident in depth with regions where seismic tomography has imaged slab stagnation, plume deflection, and changes in large-scale structure and offers a simple explanation of these phenomena. Explaining the origin of this viscosity increase represents a new challenge to the mineral physics community.